

Passively-Coded Embedded Wideband Microwave Sensors for Material Characterization and Structural Health Monitoring (SHM)

Completed Technology Project (2017 - 2019)



Project Introduction

Materials and structures are constantly subject to fatigue and degradation, and monitoring and maintaining civil, space, and aerospace infrastructure is an ongoing critical issue facing our society today. As new materials, such as complex multilayer composites, come into wider use, the need to monitor them is also rapidly growing. Space exploration adds to this need by offering extreme conditions and increased risk associated with material failure. The proposed research seeks to tackle this problem by developing passively-coded miniature embedded wideband microwave sensors, exploring their applicability, and investigating the utility of a novel and unique methodology for inspecting materials and complex structures. Each sensor will consist of a miniaturized wideband antenna specifically designed to have a number of resonances in its reflection property. By using the reflection properties of the antenna, regions in frequency of resonance and reflection can be associated with 0s and 1s to create a specific "code" for that antenna. This code shifts (in frequency) or alters based on the properties and degradation of the material in which the antenna is embedded. These sensors could be embedded in materials and structures such as concrete, a composite fuselage, or an astronaut's planetary habitat, and by being passive, the sensors will not need to be energized (i.e., wired in or provided with a power source). In the case of a planetary habitat, an astronaut could easily inspect their home for damage using a simple transceiver, and perform repairs or preventative maintenance if necessary. This practice would increase the astronaut's safety and minimize the risk of structure failure while they explore and are faced with the unforgiving environment of space. Because this technology is of such a low TRL nature, its full application range cannot be conceptualized at this point. However, with their low cost nature and versatility, these sensors have the potential to be integrated into many space structures and materials as well as everyday civil and aerospace structures like bridges, parking garages, and planes. Additionally, the sensor data could be used to refine manufacturing processes. This research will be pursued as part of an electrical engineering MS degree at Missouri S&T under the guidance of Dr. Reza Zoughi and the tools needed to engage in this research will be primarily provided through the Applied Microwave and Nondestructive Testing Laboratory (amntl) on campus.

Anticipated Benefits

With their low cost nature and versatility, these sensors have the potential to be integrated into many space structures and materials as well as everyday civil and aerospace structures like bridges, parking garages, and planes. These sensors could be embedded in materials and structures such as concrete, a composite fuselage, or an astronaut's planetary habitat, and by being passive, the sensors will not need to be energized (i.e., wired in or provided with a power source). In the case of a planetary habitat, an astronaut could easily inspect their home for damage using a simple transceiver, and perform repairs or preventative maintenance if necessary. This practice would increase the



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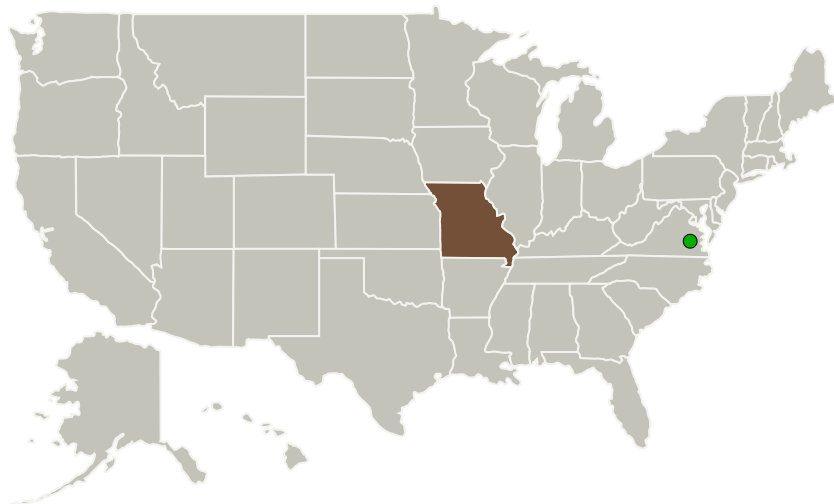
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Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Missouri University of Science and Technology	Lead Organization	Academia	Rolla, Missouri
● Langley Research Center(LaRC)	Supporting Organization	NASA Center	Hampton, Virginia

Primary U.S. Work Locations

Missouri

Project Website:

<https://www.nasa.gov/strg#.VQb6T0jJzyE>

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Missouri University of Science and Technology

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Reza Zoughi

Co-Investigator:

Katelyn R Brinker

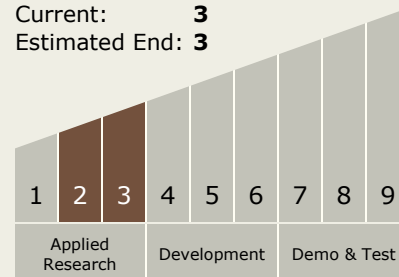
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Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX14 Thermal Management Systems
 - └ TX14.2 Thermal Control Components and Systems
 - └ TX14.2.5 Thermal Control Analysis

Target Destinations

Earth, The Moon, Mars